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CONTROL OF CUCUMBER MOSAIC IN THE GREENHOUSE

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SERIOUS CHARACTER OF CUCUMBER MOSAIC

Cucumber mosaic is one of the most serious diseases which affect cucumbers both in the field and in the greenhouse. This disease has caused extensive losses in the field for many years and occurs wherever cucumbers are grown throughout the Eastern, Southern, and Central States. The losses from mosaic in the greenhouse have been on the increase during the past five years, and at the present time the greenhouse industry in certain sections is seriously threatened by the disease. It is not uncommon to find one-third to one-half of the plants in a house destroyed by the disease within three to five weeks, and the losses in a single locality during 1922 were estimated at $75,000. In many greenhouses the cucumber is being replaced by other crops as a result of continuous losses from mosaic. It has been found, however, that the disease can be successfully controlled under glass if its nature is understood and the proper precautions are taken during the early part of the season.

DESCRIPTION OF THE DISEASE

Cucumber mosaic affects the muskmelon, squash, and pumpkin as well as the cucumber, but is most serious on the latter crop. The symptoms of the disease on the cucumber appear first on the young leaves, which become mottled with patches of yellowish green. (Pl. I.) The remaining dark-green portions of the leaf are somewhat raised and thickened, which gives the leaves a wrinkled and blistered appearance. (Pl. I.) Such leaves develop a slight curling,

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which may take place at the tip, but more often occurs along one side. This peculiar drooping of one side of the leaf is very characteristic of the disease. The older leaves of the plant also curl slightly downward and gradually turn yellow. (Pl. II.) This yellowing appears first along one of the larger veins in a V-shaped area, but soon includes the entire leaf, which eventually withers. Mosaic cucumbers will live until frost in the field, but in the greenhouse the mosaic plants usually wither and die within 15 to 20 days after the disease appears. (Pl. II.) When young plants become diseased the mottling and curling of the leaves are more marked than in the case of older plants, and the growth is immediately checked. Such plants remain in a stunted condition and rarely set fruit.

The most characteristic symptoms of the disease, however, appear on the fruits. Mosaic cucumbers are mottled with spots of light greenish yellow intermingled with areas of abnormally dark green. The dark-green patches usually become raised above the surface of the fruit and give it a peculiar warty appearance which is readily recognized. (Pl. I.) Mosaic-diseased cucumbers are also somewhat irregular in shape, and this combined with their warty character makes them of little market value. Since, in any case, the vines in the greenhouse soon die, a mosaic plant is practically a loss from the time that the disease appears. Mosaic spreads with great rapidity, and the vines become affected within so short a time that the crop is practically ruined before the grower realizes the serious nature of the disease.

NATURE OF THE DISEASE

Investigations by the United States Department of Agriculture have shown that cucumber mosaic is not caused by lack of fertility, acidity, or other soil conditions, nor is it a result of improper watering or ventilation. Cucumber mosaic is one of a group of so-called mosaic diseases which differ from most diseases of plants in that they are not known to be caused by any visible parasitic fungus or bacterium. The juices of a mosaic plant, however, contain an infective principle, or " virus," which will produce the disease if introduced into the tissues of a healthy plant. The disease is, therefore, very infectious and is transmitted from plant to plant by any agency which brings a small drop of juice from a mosaic plant in contact with a slight wound in a healthy plant. The disease occurs only when this has taken place and does not develop as a result of unfavorable soil or atmospheric conditions.

Cucumber mosaic is chiefly transmitted by insects which feed on the cucumber, the most important one being the melon aphis, or louse (*Aphis gossypii* Glover). When this insect sucks the juices of a mosaic plant and later feeds on adjacent healthy cucumbers, it introduces the mosaic juices into the wound which it makes in feeding, and the healthy plant usually develops the disease within a week or 10 days. Experiments have shown that infection is almost certain to occur when aphids are transferred from a mosaic to a healthy plant. The striped cucumber beetle (*Diabrotica vittata* Fabr.) also carries mosaic to a large extent in the field, but this insect is not sufficiently common in the greenhouse during the winter months to be of great importance.

Mosaic is also spread in pruning the vines, since the knife used to prune a mosaic plant carries the mosaic juices and brings them in contact with the wounds made in pruning healthy plants. This also holds true when shoots or leaves are pinched off with the fingers, and when the fruits are picked the juice is carried on the hands and the disease thus transmitted to other plants in the row. The evidence of such transmission can often be noted in cases where the disease first appears on a single plant and then spreads down the bed but does not affect plants in adjacent beds. In such cases it is probable that the infection has been carried down the row by pruning and handling the vines.

SOURCES FROM WHICH THE DISEASE COMES EACH YEAR

Since mosaic does not appear as a result of conditions in the greenhouse itself, but is always transmitted from one plant to another, it is evident that the disease must either live over winter in the soil, be carried in the seed or in the insects, or live over on plants other than the cucumber. Experiments have shown, however, that the disease is not carried over in the soil, even though several crops of mosaic plants are grown on the same land. Extensive trials with the seed from mosaic plants also indicate that the disease is not carried over in this manner. Repeated trials with thousands of striped beetles collected from mosaic-infected fields and kept over winter have failed to show that this insect is responsible for overwintering the mosaic disease. It has been found, however, that the disease does live over winter on certain wild plants, particularly the common wild cucumber (*Micrampelis lobata*), the milkweed (*Asclepias syriaca*), the pokeweed (*Phytolacca decandra*), and the wild groundcherry (*Physalis* sp.). In the case of the wild cucumber the disease is carried over in the seed, although this is not true of the cultivated cucumber. The other plants mentioned are perennial, and the mosaic disease lives over from year to year in their roots. Plants with such infected roots send up mosaic shoots each year, and the disease is thus carried over winter. The removal of these plants is important in the control of mosaic, since the cucumber aphis and striped beetle feed on them during the early spring and later move to the cucumber, thus carrying the disease from the wild to the cultivated plants. There is definite experimental evidence that the disease is carried to the cucumber in this way. Observations have also shown that where cucumbers are first started in greenhouses during the winter months the disease often does not appear until these wild plants have appeared out of doors.

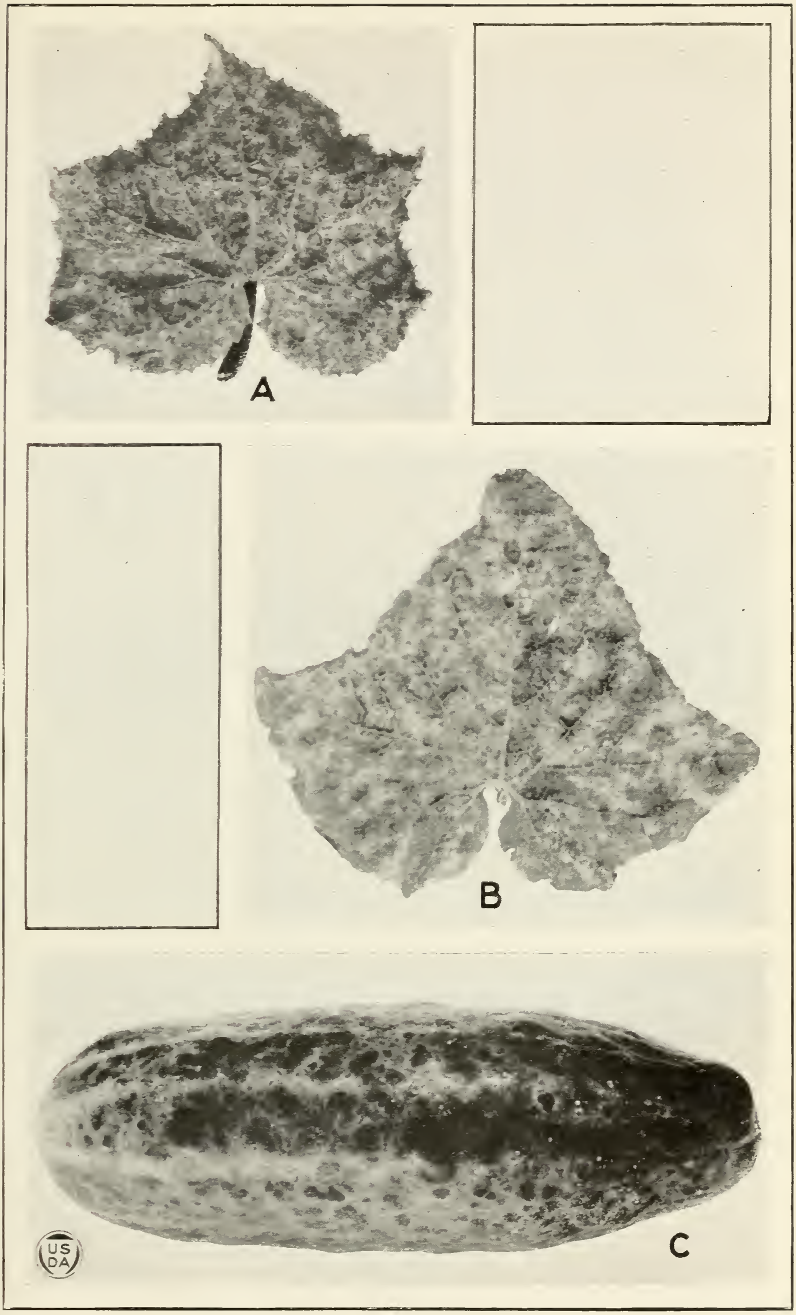
CONTROL OF MOSAIC IN THE GREENHOUSE

The control of the disease both in the greenhouse and in the field is based on the removal of the wild host plants of mosaic and the destruction of the insects which spread the disease. In the field this becomes a serious problem, but in the case of cucumbers in the greenhouse it is possible to check the disease by the use of simple measures. As one of the most important means of control lies in the removal of the sources from which it first comes, it is important that all plants of wild cucumber, milkweed, pokeweed, and wild groundcherry be removed from the vicinity of the greenhouse. Since there may be other plants not yet known which harbor the disease, it is well to keep the land surrounding the houses cultivated as cleanly as possible. If this is done the possibility of infection with mosaic will be much reduced, although the disease may often be carried into the house by insects which come from mosaic plants at considerable distances, and for this reason these measures alone will not insure the grower against the appearance of the disease.

The chief difficulty in keeping the houses free from mosaic, however, lies in the fact that a number of greenhouses are often located close together, and if the disease appears in one it will usually spread to others by means of insects which find entrance through the ventilators and other openings. It has been found, nevertheless, that it is possible to keep cucumber mosaic under control even though it has already appeared in the houses. To control the disease after it once appears, all mosaic plants should be destroyed as soon as they are found and the houses regularly fumigated to destroy insects. It is essential that those working in the houses be familiar with the symptoms of mosaic and that every plant which is suspected of being diseased be removed promptly. When plants are small it is safest to cull out those which are in anyway mottled or stunted and destroy them. When the vines become large enough to run and are intertwined with one another, the plants should never be pulled out, since the leaves and stems of the mosaic plants will then be rubbed and broken against those of the neighboring healthy plants and in this way the disease will be spread to the adjacent plants. It has been found that the safest method is to cut the mosaic plant off at the root and allow it to dry up without removing it from the trellis. The dried plant will not serve as a source of disease, as the juices of mosaic plants lose their power of infection when once dried. After handling mosaic plants healthy plants should not be touched until the hands have been washed with soap and water in order to remove the diseased plant juices. Knives which have been used to cut mosaic plants should at once be sterilized in alcohol, gasoline, or thoroughly washed, in order to avoid carrying the disease to other plants. In pruning and training the vines a sharp lookout must be kept for mosaic plants, which should be cut off at once, since they are constant sources of danger to the other plants in the house.

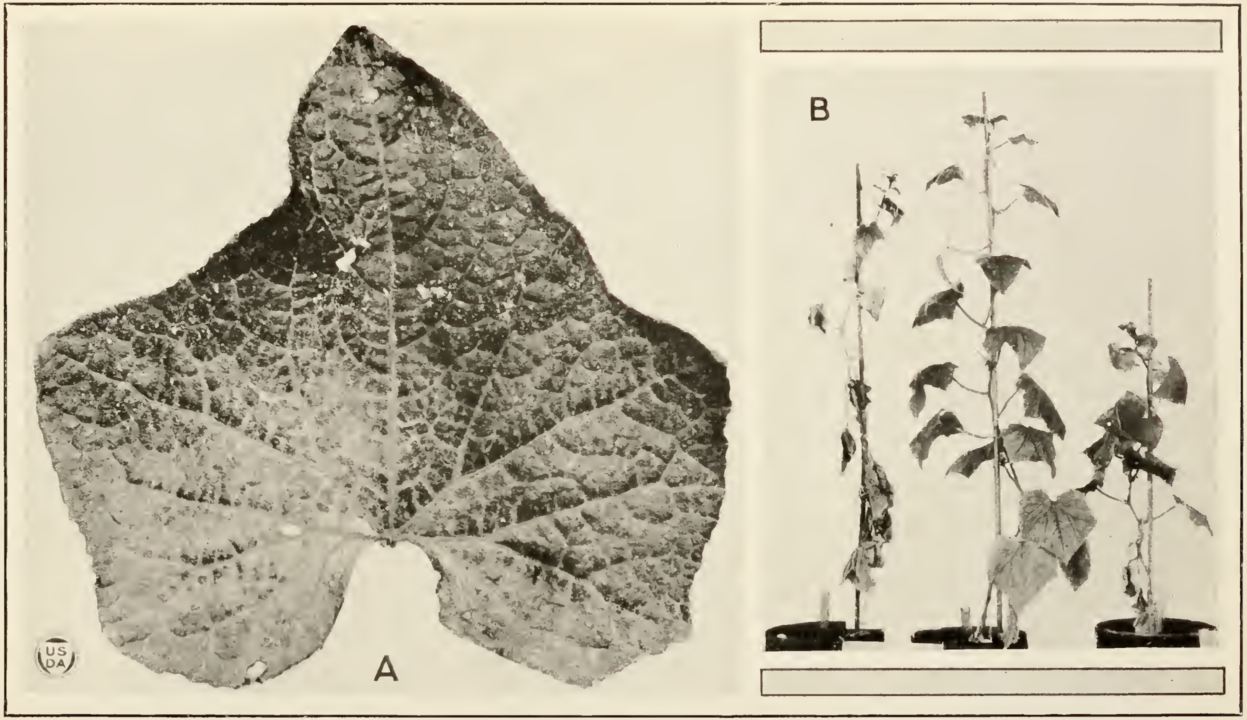
While it is important that all mosaic plants be removed as soon as they are found, it is not always possible to recognize the disease until it has been present for some days. For this reason it is absolutely essential that insects, particularly melon lice, be kept down in the houses. These insects are chiefly responsible for the spread of the disease, and if they are present in large numbers when mosaic first appears it will be a matter of only a few weeks before the crop is destroyed. It is therefore necessary to adopt a regular program of fumigation, which must be carried out from the start even though no mosaic plants have been found and the houses appear to be free from insects. Many cases have been observed where the grower did not believe that lice were present in his house, although there were a sufficient number to spread mosaic with great rapidity. These insects may be present in such small numbers that they will not be noted except on close inspection of the plants, but the numbers present will be sufficient to insure the rapid spread of the disease. It is

PLATE I



MOSAIC DISEASE OF CUCUMBER—I

A and *B*, Mosaic symptoms on young leaves, showing typical mottling and wrinkling. *C*, Greenhouse-grown cucumber, showing the mottling and warty appearance characteristic of the disease



MOSAIC DISEASE OF CUCUMBER—II

A, Older cucumber leaf, showing a type of yellowing and mottling frequently found on mosaic plants in the greenhouse. *B*, Mosaic and healthy cucumber plants grown in the greenhouse, with a healthy plant in the center. The plant at the right shows the early stages of mosaic, with many leaves curled and the older ones wilted. That at the left shows the later stage of the wilting which accompanies mosaic in the greenhouse advisable, therefore, as a measure of insurance to fumigate the houses at intervals of 10 days throughout the growing season. As previously stated, this should be done regardless of whether any lice have been noted and should be continued regularly. Good results may be secured either by the use of tobacco dust, nicotine paper, or by cyanide fumigation. General directions for the use of cyanide may be found in Farmers' Bulletin 880 of the United States Department of Agriculture. The maximum dosage for cucumbers is given by W. H. White, of the Bureau of Entomology, as three-sixteenths of an ounce of sodium cyanide per 1,000 cubic feet in an overnight exposure. The amount of nicotine in the various tobacco dusts and papers is variable, and it is therefore necessary to follow directions for their use as given by the manufacturers. Excellent results have been secured by all these methods, and the manner of fumigation, therefore, can be suited to the practice already in use by the grower.

An example of the results which may be secured in controlling mosaic in the greenhouse occurred during the spring of 1923. A grower who had lost approximately 50 per cent of his plants during the preceding year attempted to control mosaic by the methods described here, using cyanide for fumigation and fumigating at intervals of 10 days or two weeks. The plants were carefully inspected for mosaic every few days, and whenever the disease appeared the mosaic plants were cut off and allowed to dry where they were. Although the disease was found six weeks earlier than in the preceding year and was at first scattered through all of the houses, he secured practically a full crop, representing a saving of approximately $900 over the previous year. The extra expense for fumigation was estimated at $40. In this case the houses in which the disease was controlled were in the midst of a number of other houses where the control measures were not used, in all of which the disease destroyed from one-third to one-half of the plants. The conditions in this case were more severe than usual, since the disease was at first distributed through the houses and they were at all times surrounded by other houses which were full of mosaic plants.

SUMMARY

The results of the trials mentioned and other similar ones indicate that it is possible to control cucumber mosaic with a minimum of labor and expense if the fight is kept up from the beginning of the season. If the houses are thoroughly fumigated at frequent and regular intervals and all mosaic or suspected plants cut off as soon as they are found, there should be little difficulty in reducing the losses from this disease.

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